Advanced Land Imager Control Electronics*

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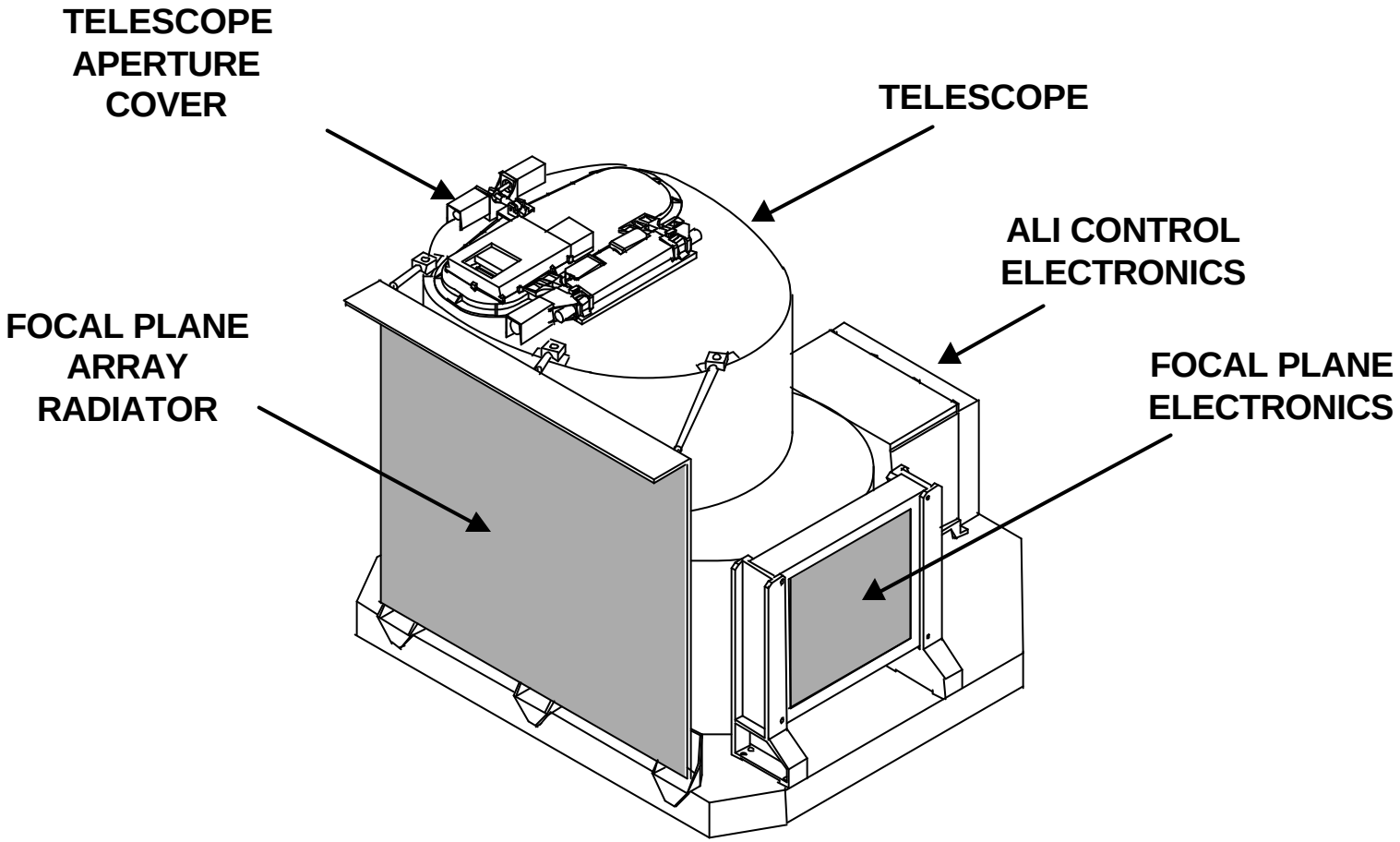
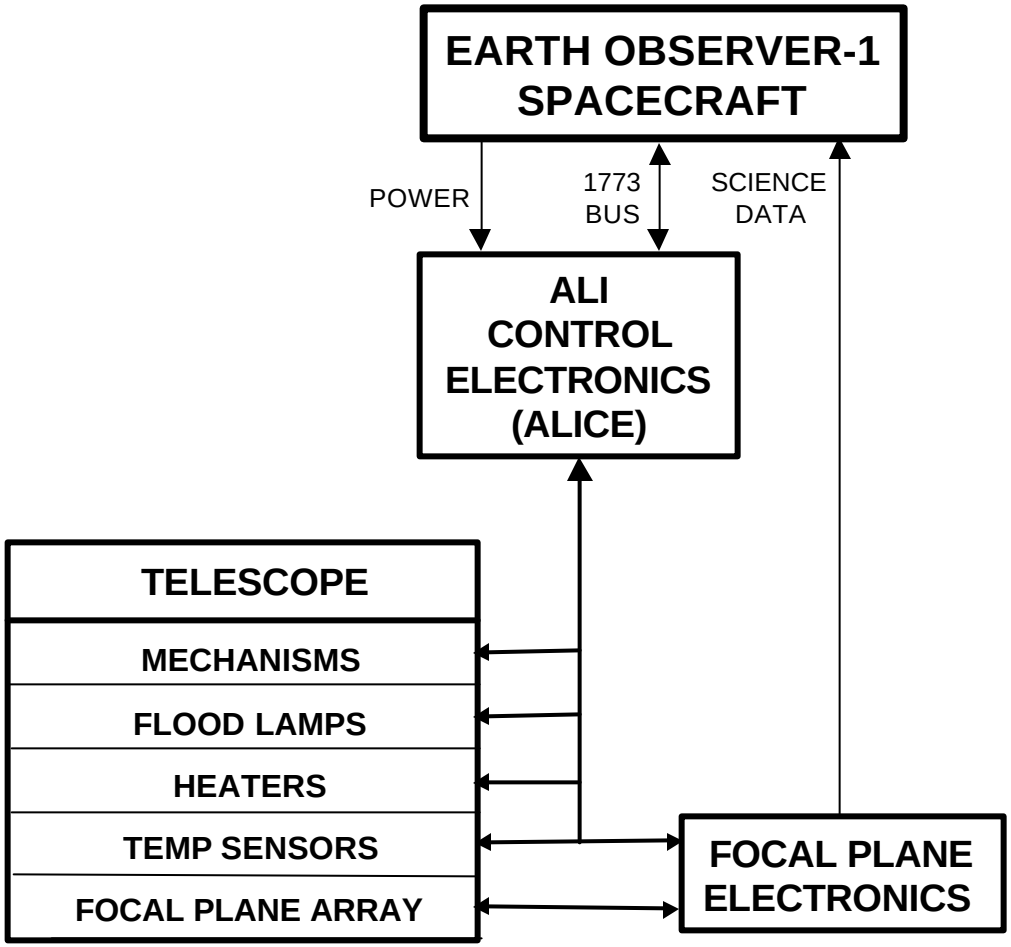
Outline

- Introduction
- ALI Control Electronics Hardware
- ALI Control Electronics Software
- Summary

Advanced Land Imager



ALI Block Diagram



Functional Requirements

- **Spacecraft Interfaces**
  - Power System
  - Command & Data Handling System
- **ALI Control Functions**
  - Mechanisms
  - Flood Lamps
  - Thermal Control
- **Focal Plane Electronics Interfaces**
  - Power and Control
  - Configuration Commands
- **Analog Data Signal Conditioning**
  - Temperature Sensors
  - Voltage and Current Monitors

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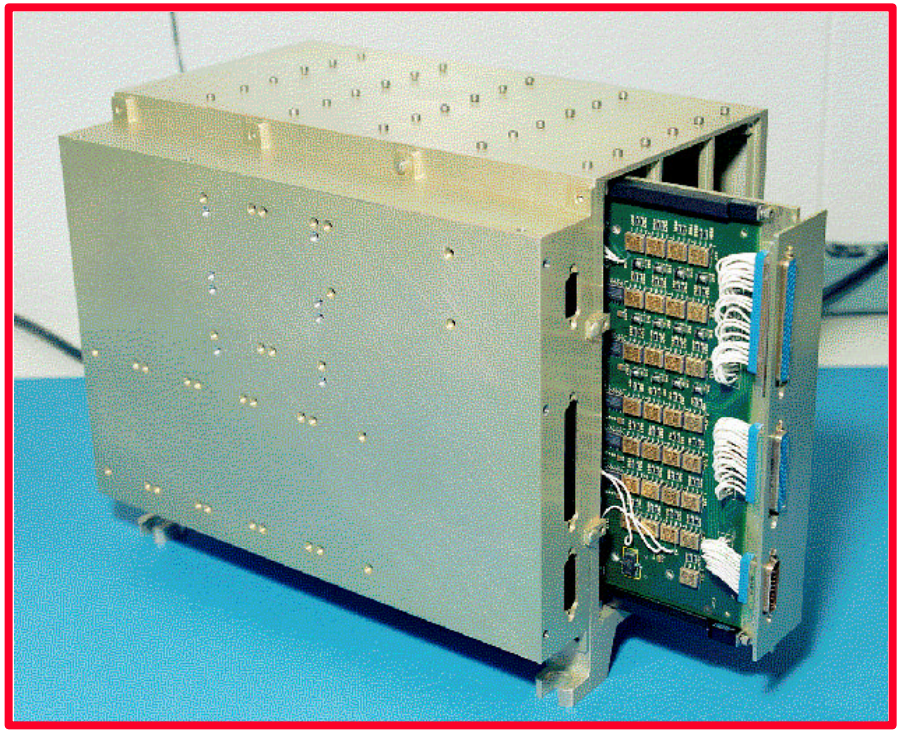
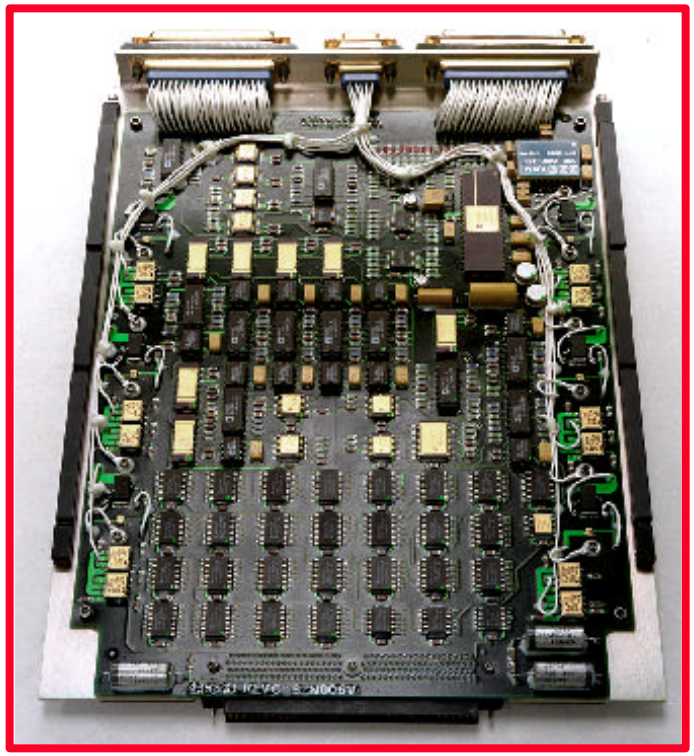
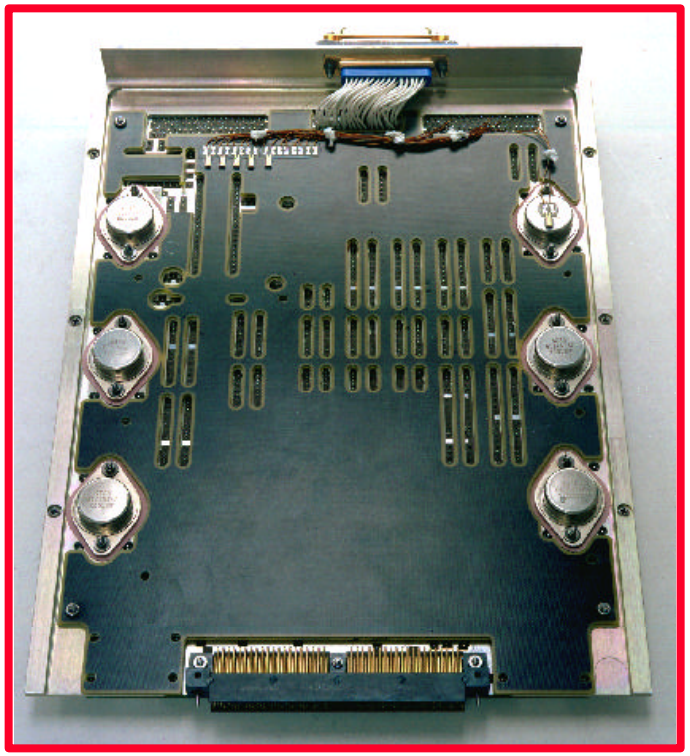
ALI Control Electronics Configuration



- Four major subassemblies
  - Remote Services Node Electronics
  - Mechanism and Thermal Control Electronics
  - Analog Signal Conditioning Electronics
  - Power Module
- Tied together by a common backplane

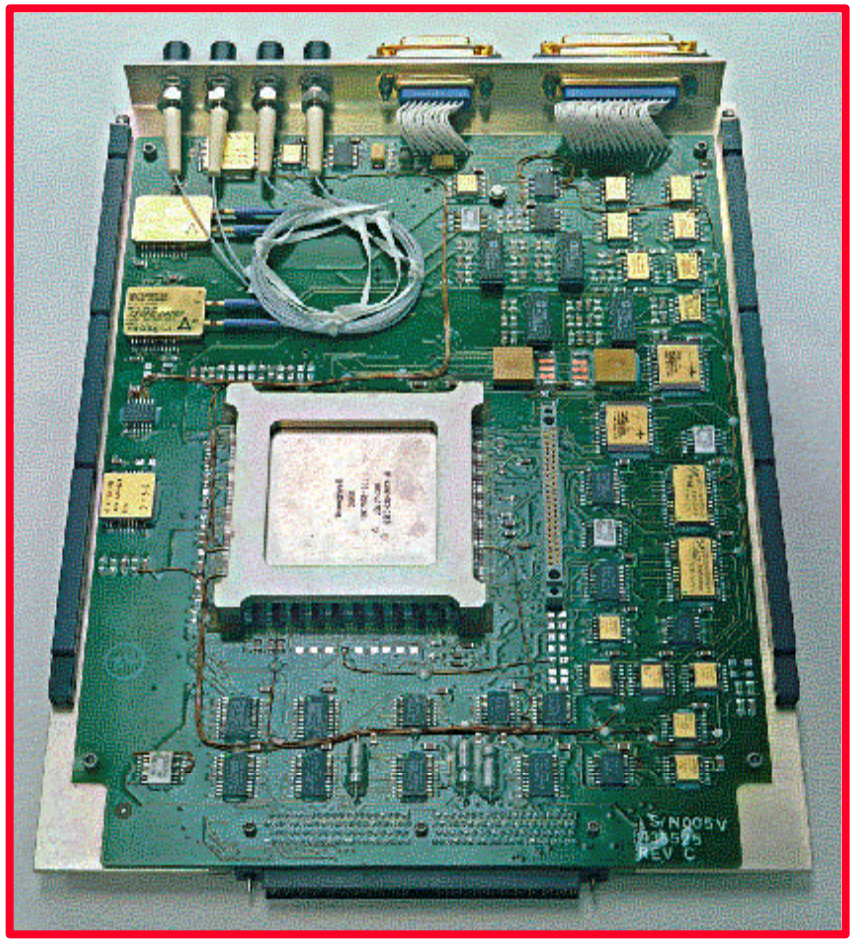
Printed Circuit Board Assembly





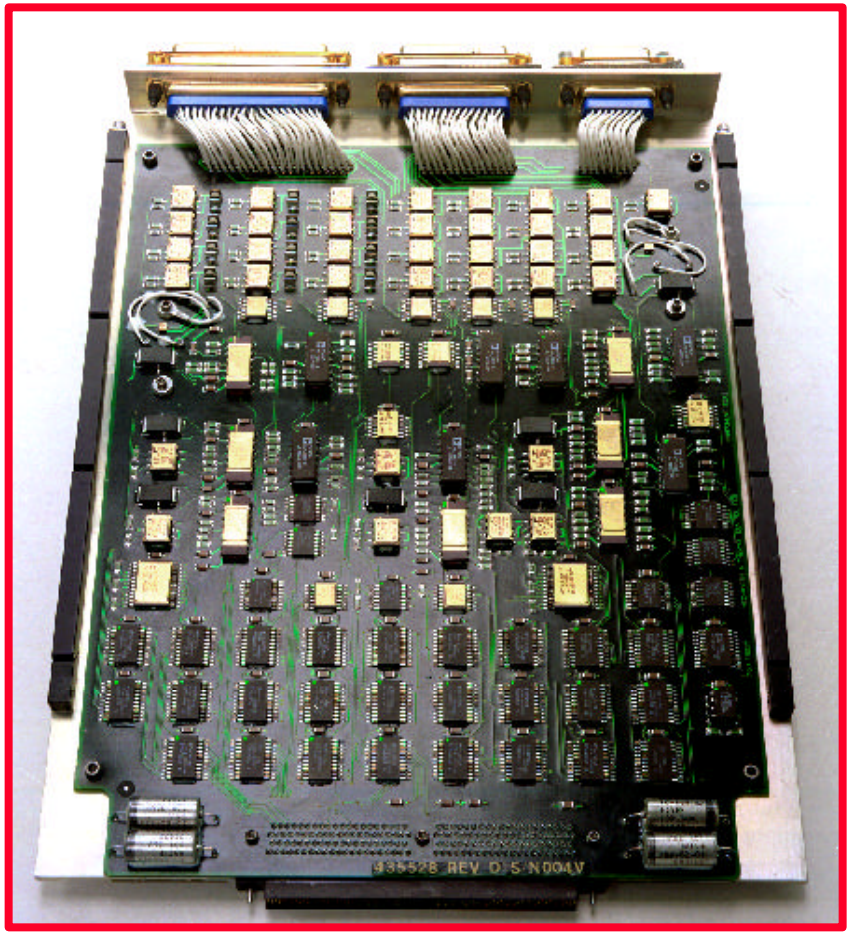
- Consists of two single-sided printed circuit boards (7” x 9”) bonded to an aluminum heatsink
- Wedgelocks used to secure assemblies in chassis card guides
  - Provide heat path to chassis exterior
- Flying leads are used to make connections to the input / output connectors

Remote Services Node Electronics



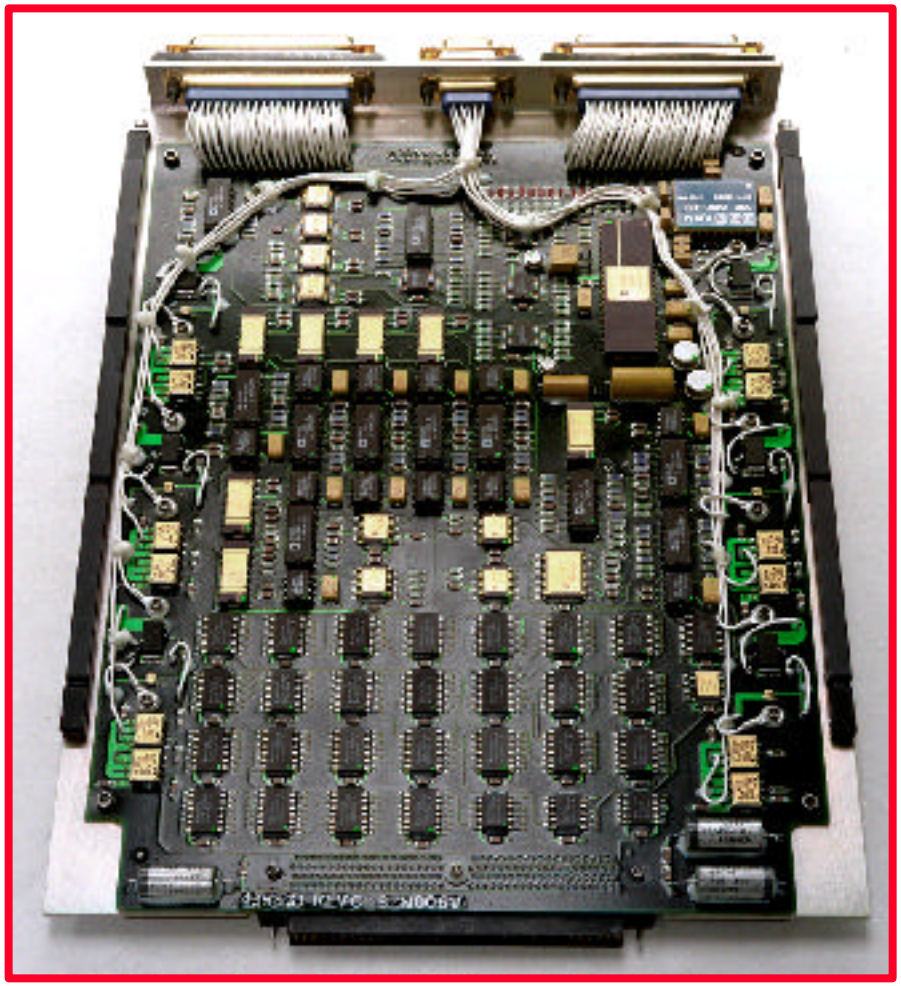
- Based on rad-hard Essential Services Node multi-chip module
  - UTMC 69R000 core
    - 16-bit microcontroller
    - Harvard architecture
  - On-board 1553 BCRTM
  - 64 KB Instruction RAM
  - 64 KB Data RAM
  - 64 KB Shared RAM
  - 8251 UART, 8254 Timer Counter, 8255 Parallel Port
  - 16-Bit Parallel to Serial / Serial to Parallel Converter
  - 12-bit A/D converter with 16 channel multiplexor
- 256 KB External EEPROM for program storage
- 64 KB External Boot PROM
- 1773 Bus Transceivers
- Operand bus backplane interface
  - Processor controls other boards using I/O reads and writes

Mechanism and Themal Control Electronics



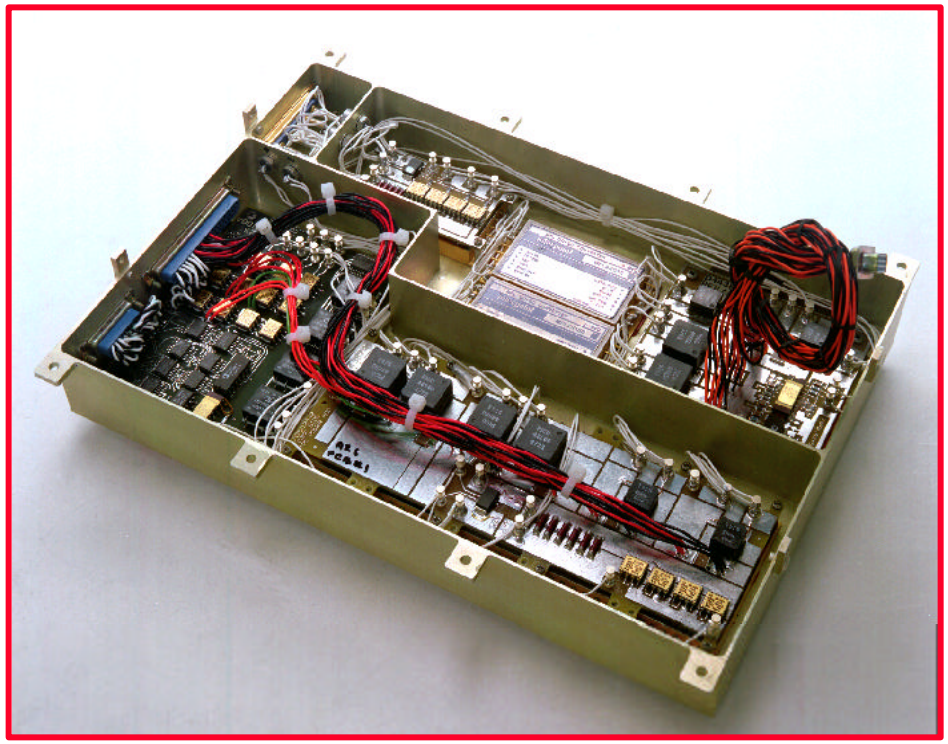
- Memory mapped control and status registers
- Opto-coupled solid state relays used for power switching
  - Mechanism motors and one-shot actuators
  - Thermal control system heaters
- Current monitors used to trip circuit breakers
  - Can be reset or disabled under software control

Analog Signal Conditioning Electronics



- Memory mapped control and status registers
- Constant current source lamp driver circuits
- Temperature sensor signal conditioning circuitry
  - AD590s distributed throughout the instrument
  - DT570 cryogenic sensors located on the FPA radiator and conductor bar
- Mechanism position sensors

ALI Control Electronics Power Module



- Spacecraft primary power interface
- Provides unswitched +5V and +/- 15V power to the ALICE assemblies
- Provides switched +5V and +/- 15V power to the Focal Plane Electronics
- Provides voltage and current monitor outputs

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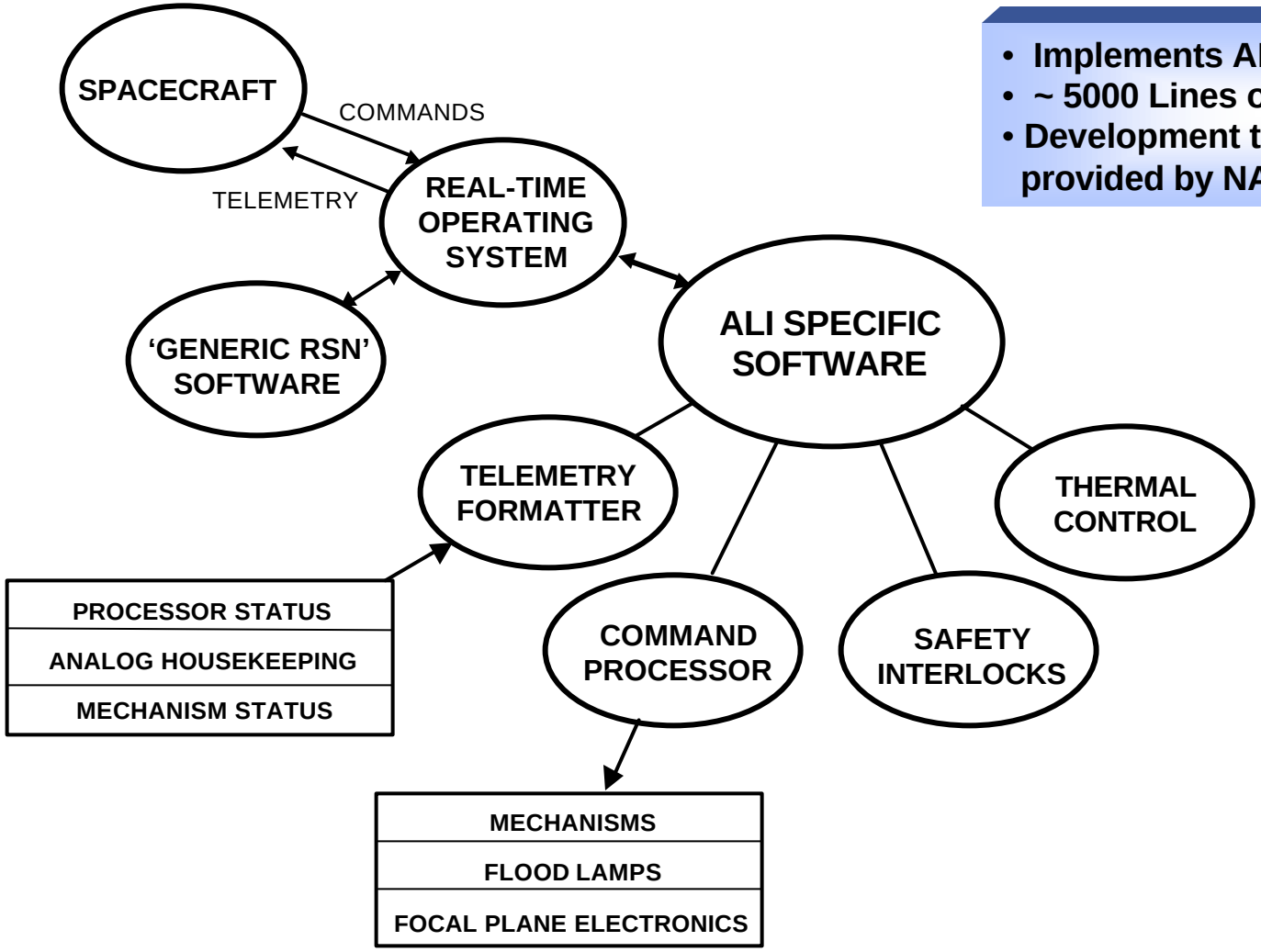
ALICE Software



- Implements ALI Functionality
- ~ 5000 Lines of 'C' Code
- Development tools and utilities provided by NASA/GSFC

Development Tools and Utilities

- Development Tools
  - PC-based ‘C’ compiler, assembler and linker
  - No in-circuit emulator available for this system, logic analyzer used to trace program execution
  - Command & Data Handling system simulator purchased from Jackson & Tull
- Utilities
  - “BOOT”
    - Stored in on-board PROM
    - Transfers executable image from EEPROM to IRAM upon reset
  - “MONITOR”
    - Stored in on-board PROM
    - Invoked by depressing spacebar during reset
    - Uses on-board serial port to communicates with PC to perform various functions
      - View IRAM, DRAM, EEPROM, CPU registers, memory-mapped I/O
      - Modify IRAM, DRAM, EEPROM, CPU registers, memory-mapped I/O
  - “EEPROM”
    - PC-based utility that translates linker output files into Intel Hex format so they can be downloaded into the on-board EEPROM
  - “LOADER”
    - PC-based utility that communicates with “MONITOR” to store an executable image into the on-board EEPROM

RSN Operating System

- RSN OS developed jointly by GSFC and Daedalian Systems, initially in support of the Microwave Anisotropy Probe (MAP) program
- "... provides a kernel of useful services that support multitasking and preemptive scheduling"
  - Based on a 2 kHz timer interrupt
  - Time keeping
  - Memory management
  - Application task scheduling and execution
    - Tasks implemented as 'C' functions and linked with OS libraries to create an executable image
  - Intertask communications via software bus
  - Watchdog timer maintenance
- 1773 Bus transactions
  - OS handles all incoming (outgoing) command (telemetry) packets (assumes CCSDS* format)
  - OS routes the packets to the appropriate tasks using the application ID field of the CCSDS header

*Consultative Committee for Space Data Systems

Generic RSN Software

- Generic RSN (GRSN) Software consists of a set of "application" tasks that reside above the OS
  - Developed by GSFC to provide utilities common to all RSN subsystems, implemented as low-priority background tasks
- Functional Overview
  - Initialization Utilities
    - Warm and cold restart commands
  - Memory Loads & Dumps
    - Instruction RAM and Data RAM loads
    - Boot PROM, EEPROM, IRAM and DRAM memory dumps
  - Health & Safety Functions
    - Checksum validation and maintenance for all memory areas
    - Watchdog Services
    - Housekeeping Telemetry
      - Command counters
      - Checksum status
      - OS status

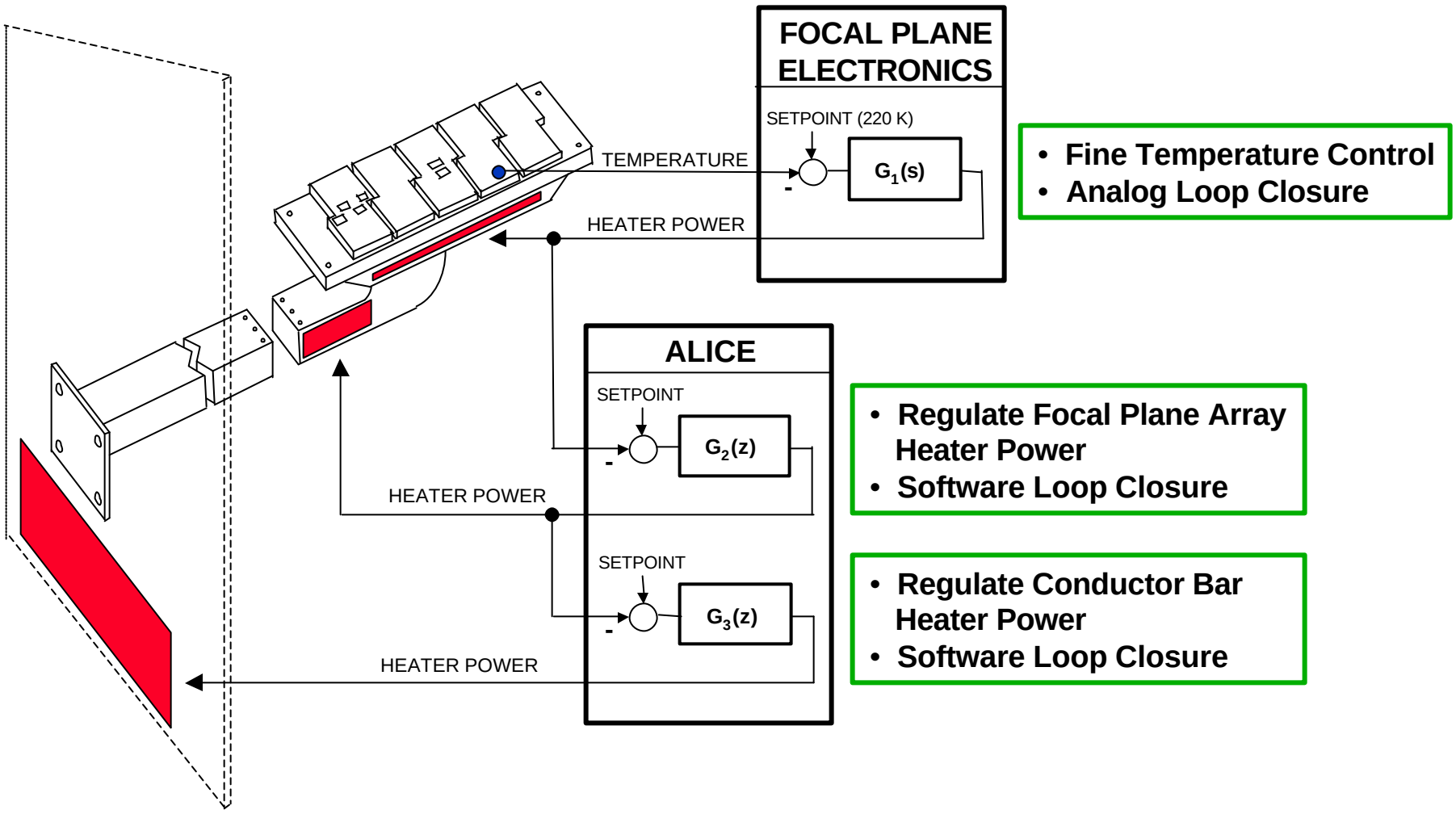
Application Task Summary

- Four ALICE specific tasks were implemented
  - Command Processor Task
    - Processes ground commands received over the 1773 bus
    - Processes stored commands received from the Stored Command Processor Task
    - Executes when a command packet is placed into the task inputs queue
  - Stored Command Processor Task
    - Sends stored commands to the Command Processor Task at the time they were scheduled to be executed
    - Executed at a rate of 500 Hz
  - Motor Control Task
    - Updates the phase excitation of the mechanism motors
    - Active only when mechanism is being used
  - "Slow" Task
    - Runs at a rate of 1 Hz
    - Collects analog housekeeping signals
    - Performs thermal control functions
    - Performs Health & Safety functions
    - Sends housekeeping and diagnostic packets to the OS for transmission over the 1773 bus

ALICE Command Structure

- Total of 37 commands were defined and implemented
  - Mechanism Control
    Enable and activate mechanisms, Arm and fire one-shot actuators
  - Flood Lamp Control
    Enable and activate lamps
  - Focal Plane Electronics Configuration and Control
    Enable / Disable FPE power and data gate, Set line rate and integration time, Set FPA temperature setpoint
  - Thermal Control System Commands
    Enable / Disable, Automatic / Manual, Mode control, Setpoints
  - Data Collection Commands (macro type commands)
    Earth Observation, Flood Lamp Calibration, Solar Calibration
  - Miscellaneous Utilities
- Many commands were parameterized to increase flexibility and robustness

Focal Plane Array Thermal Control



- Fine Temperature Control
- Analog Loop Closure

- Regulate Focal Plane Array Heater Power
- Software Loop Closure

- Regulate Conductor Bar Heater Power
- Software Loop Closure

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Summary

- ALI Control Electronics have performed flawlessly in over nine months of on-orbit operations
  - No reported hardware anomalies
  - Very robust software architecture
    - To date, no software patches have been necessary
- Although the Essential Services Node has been proven to be a very reliable system controller, future missions must seek alternatives
  - Essential Services Node no longer available
    - Existing stock or direct replacements may become available
  - Several rad-hard candidate substitutes are available
    - Modest computational requirements
    - Development tools and utilities
    - Operating system requirements